

RESEARCH ARTICLE

## Analysis of Rigid Pavement Using Kenpave Software

\*NAVEEN B C<sup>1</sup>

<sup>1</sup>Department of Civil Engineering, Assistant Professor, Sreyas Institute of Engineering and Technology, Hyderabad, India.

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### ABSTRACT

When replaced with Natural aggregate, the Recycled aggregate has emerged as a major alternative to the conventional concrete in rigid pavement construction and has rapidly drawn the concrete industry attention due to its aggregate savings, energy savings and cost savings, environmental and socio-economic benefits. Recycled aggregate content has been found to be of use as part of the replacement of natural aggregate. Amidst growing awareness of natural resources, search for new material technology in the construction technology without sacrificing the quality and property of the material is the need of the day. In the above context an attempt is made, in the present study, to examine the possibility of replacing Natural aggregates by Recycled aggregates. The replaced material up to certain limits showed a very good compressive strength and concrete properties. Carrying these results to the KENPAVE software, an analysis is done on the concrete pavement of size 3.5 x 4.5; and, various stresses are found out using this software. The stresses for wheel loads of a single wheel, two wheels of a single axel, four wheels of two axels, six wheels of three axels for different positions in the slab likely corner, edge, middle for poisson's ratio varying from 0.15 to 0.2 is analyzed. Results are tabulated and a discussion is presented on this analysis, which showed a tremendous change on replaced material.

**Keywords:** Recycled aggregate, KENPAVE, Stresses and wheel, loads, poison's ratio, wheel axels, Slab thickness and Thermal stresses.

### 1. INTRODUCTION

Recycled concrete aggregate consists mostly of inert and non-biodegradable material such as concrete, plaster metal, wood, plastics etc. A part from this waste comes to the municipal stream. It is estimated that the construction industry in India generates about 10 to 12 million tons of waste annually. A projection of building requirement of the housing sector indicates the shortage of aggregates to the extent of about 55,000 million cu. m; an additional 750 million cu. m aggregate would be required for achieving the targets of the road sector. Recycling of aggregate material from construction and demolition of waste may reduce the demand-supply gap in both these sectors. Disruption, Waste from small generators like individual house construction or demolition consists of 10 to 12% of the municipal solid wastes. While retrievable items such as bricks, wood, metal are recycled, the concrete and masonry waste

accounting for more than 50% of the waste from construction; and, demolition activities are not being currently recycled in India [1,2]. Recycling of concrete and masonry waste is however being done abroad in countries like the USA, France, Denmark etc. Concrete and masonry waste can be recycled by sorting, crushing and sieving into recycled aggregate[3,4]. This recycled aggregate can be used to make concrete for road construction and building material. Work on recycling of aggregates has been done at Central Building Research Institute (CBRI), Roorkee and Central Road Research Institute (CRRI), New Delhi. Figure 1.1 shows a typical photo of recycled aggregates.

### 2. OBJECTIVES

The main objectives of this project are as follows:

- Characterization of demolished aggregate;

\*Corresponding author. Tel.: +91 7382727777

Email address: [naveenbc83@gmail.com](mailto:naveenbc83@gmail.com) (Naveen B C)

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- Modelling rigid pavement for different load groups i.e. Single axle single and dual wheel, two axle dual wheel and three axle dual wheel for optimum percentage of recycled aggregates;
- Estimating the stress at edge, corner and centre for these load groups for different thickness and poison's ratio;
- Estimation the variation of temperature stress for different thickness; and,
- Stress for various load combination is estimated.

### 3. SCOPE

The scope is limited to the use of materials chosen for the experiments, which are:

- Ordinary Portland cement 43 grade;
- Locally available crushed angular coarse; aggregates of maximum size 20 mm;
- Locally available building demolition waste;
- Locally available river sand;
- Portable water; and,
- Code specified super plasticizers

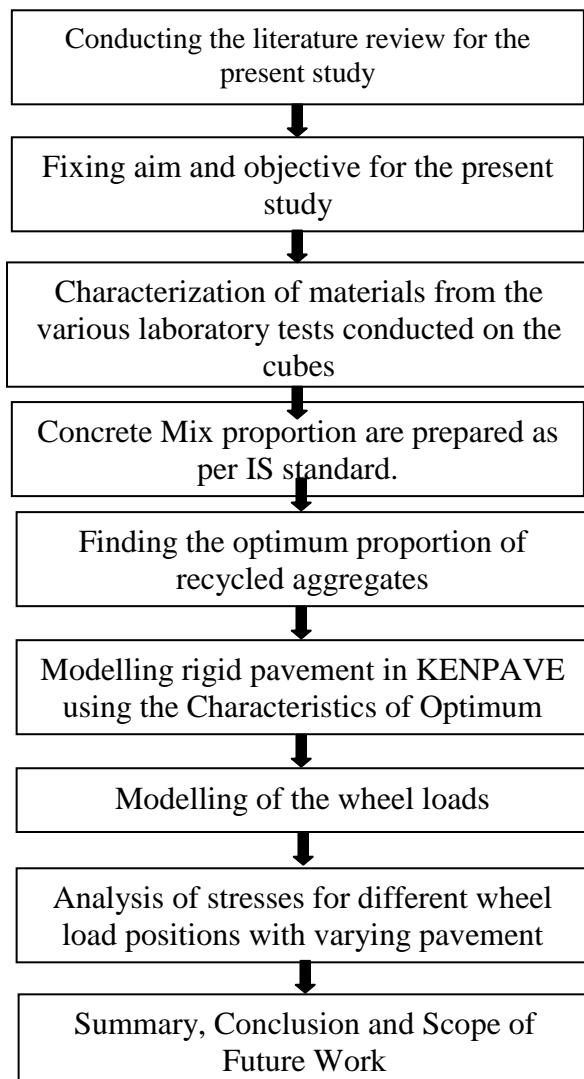


Figure 1 Methodology of study

### 5. TEST SPECIMENS AND TEST PROCEDURE

The concrete cubes of 150 mm size have been used as test specimens to determine the compressive strength concrete and modulus of elasticity of concrete for both the cases i.e., nominal concrete and recycled aggregate modified concrete. Concrete cubes of size 150 mm were casted with recycled aggregate from 0 to 50% with 5% increment levels as shown below. The ingredients of concrete were thoroughly mixed till uniform consistency was achieved. Figure 2 shows a typical photo of fresh concrete cube with 20% replacement of recycled aggregates and Figure 3 shows Test specimens

### 4. METHODOLOGY

The methodology for the given study as shown in Figure (1):



Figure 2 Concrete cubes with recycled aggregates



Figure 3 Test specimens

### 5.1 Compressive Strength (Is 516: 1959)

Concrete cubes of dimensions 150x150 mm have been cast for compressive strength. After 24 hours of casting, the specimens stripped and were kept for curing. After 28 days, the specimens were removed from the curing tank. Compressive strength test has been conducted on compression testing machine of the capacity of 20000 KN. The specimen was gradually loaded till failure occurred. After knowing the failure load, compressive strength has been calculated by the equation: Compressive strength =  $P/A$  where  $P$  = Failure load,  $A$  = Cross sectional area. After 28 days and 90, the variation of compressive strength for various properties of recycled aggregates is given in Table 1.

Table 1. Compressive Strength And Modulus Of Elasticity Of M40 Grade Concrete With Various Percentages Recycled Aggregate Replacement With Natural Aggregates.

% of replacement of coarse aggregate	Compressive strength @ 28 days (Mpa)	Compressive strength @ 90 days (Mpa)	Modulus of elasticity (N/mm <sup>2</sup> ) x 10 <sup>5</sup>
0	43.4	49.2	0.35
5	45.3	49.8	0.35
10	49.2	59.2	0.38
15	50.5	60.5	0.39
20	49.4	68.6	0.41
25	48.2	62.5	0.4
30	43.6	61	0.39
35	34.5	60.6	0.39
40	36.7	62.4	0.39
45	32.4	58.3	0.38
50	37.3	56.4	0.38

Compressive strength was found to vary from 32.4 Mpa to 50.5 Mpa. A higher value of compressive strength was obtained for a 15% replacement of coarse aggregate for 28 days and 20% replacement of coarse aggregate for 90 days. Above 30% replacement of coarse aggregate, it was found that compressive strength has gone below 40 Mpa. The modulus of elasticity was found to vary between 0.352 and 0.414.

### 5.2 WHEEL LOADS

Stresses in rigid pavement depend upon gross load, tire pressure, the spacing of multiple wheels, the position of loading on the pavement etc. In the present study four load groups were considered for the analysis of stresses in the rigid pavement. These are as follows.

1. Single Axle single wheel – Load group A (Figure 4)
2. Single Axle dual wheel – Load group B (Figure 5)
3. Two Axle dual wheel – Load group C (Figure 5)
4. Tridem Axle two wheel – Load group D (Figure 6)

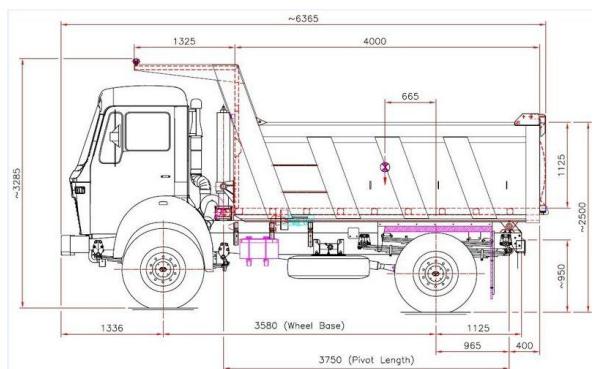


Figure 4.Single Axle dual wheel load

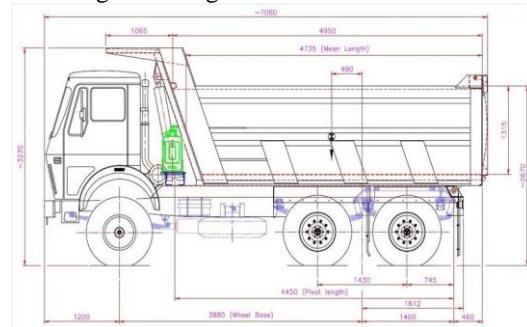


Figure 5.Two Axle dual wheel load

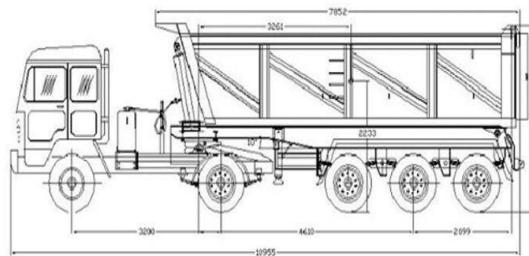


Figure 6.Tridem Axle dual wheel load  
KENPAVE SOFTWARE



Figure 7.Kenpave Main Page  
OUTPUT OF KENPAVE SOFTWARE

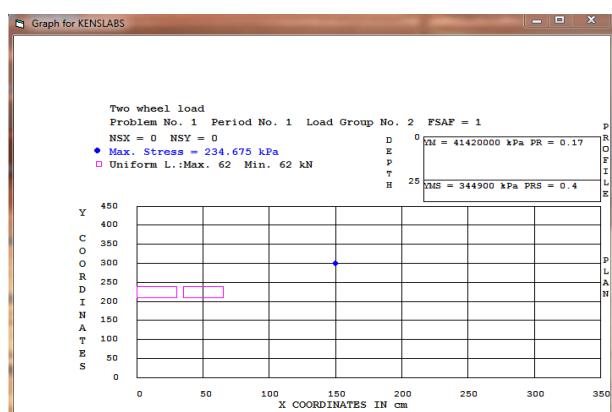
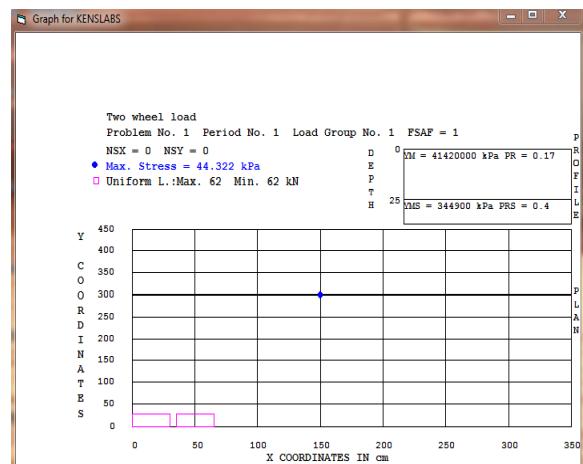


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Figures 7, 8, 9 (Output of KENPAVE software for corner, middle and edge stresses.

Table 2.Stress result for single wheel load for poisson's ratio 0.15

Thickness of slab in cm	Corner stress in Kpa	Edge stress in Kpa	Middle stress in Kpa
10	5.906	78.332	447.679
15	8.005	118.48	246.876
20	11.82	132.79	-249.56
25	20.309	130.87	-237.85
30	32.191	121.26	-218.01
35	44.298	108.93	-195.71
40	54.351	96.396	-173.45
45	61.429	- 89.127	-152.75
50	65.522	- 86.838	-134.09

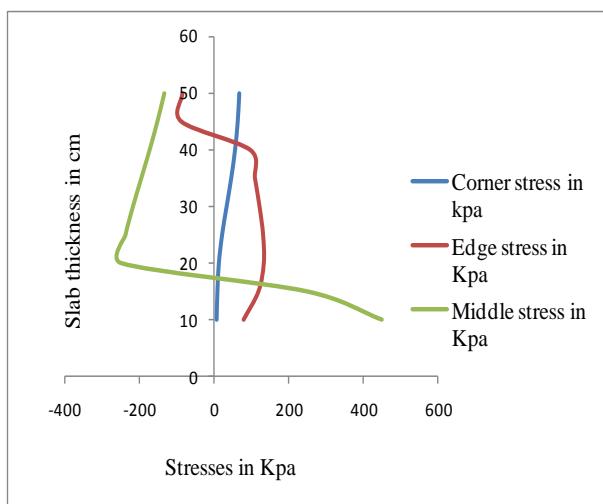


Figure 10. Stress variation vs. slab thickness

## 6. RESULTS AND CONCLUSIONS

The Output of KENPAVE software for corner, middle and edge stresses as shown in Figure 7, 8 and 9.

This study presents the results of an experimental and analytical work related with the failure and mechanical behavior of Recycled Aggregate (RA) under different load scenarios. The particular type of RA considered herein is characterized by the partial or total replacement of natural coarse aggregates by recycled ones obtained from the crushing of waste concrete. The aim of this research is to deepen the existing knowledge related to RACs by analyzing the degradation in physical and mechanical properties when recycled coarse aggregates are used. Eleven different mixes of recycled aggregates (0 to 50 %) were used to find the optimum recycled aggregate content. It was found that 28 days characteristic strength was found maximum for 20% replacement of the normal aggregates.

Conventional test on recycled aggregate was carried out. It was found that a slight decrease in specific gravity of the recycled aggregate (2.51), compared to the normal aggregate (2.67). Water absorption was found to be high (4%) as compared to normal aggregates (0.2%). A slight increase in crushing strength was observed for RA compared to normal aggregates NA. Abrasion value is found to be high due to the presence of fine aggregate coated around RA. This can be reduced by further cleaning of RA. Flakiness and elongation index is found to be less compared to RA.

A rigid pavement was modeled on KENPAVE using the characteristics value obtained from experimental results. This was analyzed for different load groups, thermal loads and load combinations. The results from the analysis are explained in the following paragraphs.

With respect to poison's ratio a slight change in stress was observed for a given load group. The corner

stress was found to increase with the thickness of the slab. This may be due to increase in the self weight of the slab. Comparing with different load groups, load group D creates more stresses compared to the other load groups.

The variation of temperature stress was found to be less for different poison's ratio. It was found that the temperature stress takes an optimum value with variation in thickness. The optimum value of the thermal stress was found between a thickness of 20 to 25 cm as shown in Figure 10. The thermal stresses was found more than the wheel load stress.

## REFERENCES

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